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ENGINEERS' REPORT,

October 19, 1869.

New-York:
JOHN W. AMERMAN, PRINTER,
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ENGINEERS' REPORT.

To the Honorable Wm. B. Ogden,
President of the New-York City Central
Underground Railway Company:

Sir:

We have the honor to lay before you the following report in reference to building and working an underground railway in this city:

In deciding on a plan or system, under which to construct a public work, with moneys drawn from the pockets of individuals forming an association, the first question asked and the most important one to decide, as far as those individuals are concerned, is, will it pay? If it will not, then it should not be attempted, unless as a national or State work. We hope to show at the conclusion of this paper, that the work in question will pay, and that it can be made an eminent success, giving facilities of the utmost importance to this city, already large, and destined probably to become the important commercial city of the world.

In planning a work of this kind, it will naturally be expected that the London Metropolitan Railway would be looked to, as furnishing most important experience, and probably bearing as a guide. That great work has been visited by one of our number, and studied by us all, but the conclusion arrived at is, that we cannot well afford to carry out a similar work in this city and in all respects in a similar way. We cannot afford to build a work of this kind, and leave forty per centum of the area occupied open overhead, to obtain ventilation, rendering it forever useless for any purpose save that of the Railway. The land, in the lower part of the City of New-York, is worth from one to three millions of dollars an acre, independent of the buildings. Now, as the Railway will occupy more than four acres per mile, it must be evident to any one that if the land is bought for the Railway, and not afterwards utilized for building purposes, the item for "right of way" will appear in the Company's account in fearful figures. We are satisfied from this investigation that you must adopt some plan of structure different from that of the London Metropolitan Railway, or abandon the project; although that line, with all its cost, is reported a successful commercial enterprise, paying regular dividends.

We believe that your Railway should be arched over for its whole length, excepting where it may have stations in parks and public squares, which may be left open overhead, without cost to the Company; there are several such places on the proposed line. Having decided that the line must be arched over, for the whole distance, it becomes clear that it should be located, as far as possible, along and under streets, where the right of way can be obtained free from cost. This great point, the right of way, being disposed of, the next point to be considered is the power to be used in working a railway under a continuous arch, and at the same time have sufficient ventilation; this is in reality the chief engineering problem to be solved. To obtain the end sought, it becomes necessary to have a power that can be relied on to haul long and heavy trains with safety and speed, that these trains shall follow each other at very short intervals, and that the atmosphere of the tunnel shall be kept good all the time. Knowing the objections to the ordinary locomotive engine manufacturing its steam as it runs by a fire within itself, we have given much study to the various means proposed for getting rid of these objections. The pneumatic system of propulsion, which seems to be already established for the conveyance of packages, promises very valuable results ultimately, in its application to passenger transit, as shown by the Sydenham experiment. But as this is still a practically unsettled question, we do not propose any thing in the first construction of the Railway that would, in any way, interfere with the use of the ordinary locomotive engine.

The gravity system has some interesting features in it. By "Gravity System" is meant a road having all the stations on summits, with steep inclines running to and from them, and between the feet of these steep inclines other inclines, descending in the direction the traffic is to run, and arranged to obtain any required speed, from 20 to 40 miles an hour. We consider this system inapplicable to your road.

The "Compresed Air Engine System" has some features worthy of note, but it is impossible to carry in any ordinary size reservoir sufficient air to haul a large train any profitable distance. The heat generated in compressing the air, if done rapidly, would be a difficulty to provide against, and the low temperature, obtained by expansion in the cylinders and the exhaust ports, might cause ice to form in the cylinders and clog the engines.

Motive power, stored up in the form of water heated to a very high temperature, promises very satisfactory results, and having been carefully looked into by one of our number, will be found described, and its prominent advantages dicussed, in Appendix A. As before stated, however, we think it best to recommend nothing, in the first construction of this road, that could interfere with the use of the ordinary locomotive engine; leaving the expediency of adopting other kinds of motive power to be determined by future experience.

Before leaving the matter of the power to be used in working this Railway, we would say, that at first we took it for granted that to ensure proper ventilation, a large portion of the line must be left open overhead, as was done on the London Metropolitan Railway; we are now inclined to think that a most perfect ventilation can be obtained by the use of large ventilating chimneys and steam engines driving fans, or steam jets, placed half way between stations, and so arranged that they can change the entire atmosphere of the tunnel in a very short period, with trains running in each direction every three minutes. This will give as good an atmosphere as will be desired.

This system could be carried out at less cost than the hot water system, but it would have connected with it a certain amount of annoyance from cinder and smoke, which the hot water system is free from.

In order to save the very large amount of power lost by stopping trains at so many stations, it has been proposed to make the longitudinal section of the road undulating, so that the stations may be on summits, thus permitting gravity to be used for stopping and starting the trains. We believe it best, however, to leave the settlement of this question for future consideration. A discussion of this subject by one of our number will be found in Appendix B.

We have examined the routes designated by the charter, and have estimated the cost of construction on the street line, in preference to the line through the blocks by open cuts on the sides of the streets, as we believe the former is most advantageous for the interests of your Company. The line of the Railway commences on Broadway in the City Hall Park, thence by a double line on each side of the City Hall to Centre-street, and through City Hall Place to Worth-street; thence to the angle of Mulberry-street, and through Mulberry and across the blocks between Bleecker and Great Jones streets, to and through Lafayette Place and Astor Place, and through the block between Eighth and Ninth streets to Fourth Avenue, and through Fourth Avenue and Union Square to Seventeenth-street, and through the blocks between Seventeenth and Twenty-third streets to Madison Square and Madison Avenue, and through Madison Avenue to Harlem River, and along Harlem River to Harlem River Bridge on the Third Avenue.

This route, passing very nearly through the middle of the Island, and less than one-fifth of a mile from the Central Park, throughout its extent, has all the advantages for through or local travel which any route can possess.

The location of the route near City Hall Park, and at Madison Square, offers great facilities for connections with the Brooklyn Bridge, (recently authorized,) and for extensions to the East and North Rivers, and their numerous ferries, or to the Rail-Roads on the Eighth or Ninth Avenues, near the Central Park, or to Tunnels which may be constructed connecting Brooklyn, or the New-Jersey shore with New-York.

The northern terminus at Harlem River is not less advantageous for passenger traffic, ending as it does in the rapidly growing section of the city on Harlem Plain, and opposite the populous and rapidly-increasing villages of Westchester County, and affording, as it does, facilities for continuing a railway westerly along Harlem River, as authorized by the charter.

The route passes within two hundred and fifty feet of the contemplated passenger station, between Forty-second and Forty-fifth streets, where it is contemplated to concentrate the passenger stations of the three great rail-roads entering the city from the north and east, and crosses the line, by which the passenger traffic of these roads will enter the city at Harlem River.

The stations to be at each half-mile, nearly, the positions to be hereafter determined on due consideration of the cross-town travel and the centres of trade.

The estimate (excepting on the low grounds of Harlem, north of Ninety-ninth-street, where the charter authorizes the road to be carried over the street, and where the estimate is for a viaduct) is for a covered tunnel for the entire route, lined with masonry, lighted and thoroughly ventilated, by ventilating shafts and power, at intermediate points between the stations, with a capacity to remove the smoke and gases with a rapidity which shall insure pure air in the cars at all times.

The construction of a double tunnel has been considered; it would increase the probable cost of the work but little, if any, and would greatly facilitate ventilation; it would also render it possible to experiment on the pneumatic mode of propulsion, as tried at Sydenham, where results were obtained which seem to indicate great economy in moving trains, and an absence of difficulty with regard to ventilation. This could be done, in a tunnel so nearly suited to this method, without additional expense of construction.

A telegraph line will be arranged in the tunnel, by which communication can be made with any train, in case of delay, so that assistance can be promptly given.

Estimate of the Cost of Constructing and Furnishing the New-York City Central Underground Railway from City Hall Park to Harlem River.

Section First—From City Hall Park to 46th-street.

633,990 cubic yards of earth excavation, including drainage, sheet piling and bracing, and re-filling over the masonry, at $1 50 per cubic yard,....	$950,985	
56,000 cubic yards of rock excavation in Tunnel, at $6 per cubic yard, ...	336,000	
502 cubic yards of rock in Shafts, at $20 per cubic yard, ...	10,040	
Raising and repaving streets,..................	200,000	
Changing water pipes, &c.,.....................	125,000	
Changing sewers, &c.,.........................	180,000	
For grading,...		$1,802,025

Brought forward, ...		$1,802,025
74,088 cubic yards of brick masonry, at $16,.....	$1,185,308	
68,600 " " rubble masonry, at $10,....	686,000	
58,800 " " concrete, at $8, ...	470,400	
		2,341,708
10 miles of single track and ballast, ...		395,500
8 depots and stations, at $50,000, ...	$400,000	
Repair shop, and engine house and sheds, ...	250,000	
Telegraph and gas fixtures, ...	30,000	
7 ventilating stations, shafts and machinery,....	330,000	
		1,010,000
27 Engines, at $16,000, ...	$432,000	
200 Passenger Cars, at $5,000,.................	1,000,000	
		1,432,000

LAND DAMAGES.

From Worth to Mulberry streets, 750 feet, at $300,	$225,000	
From Bleecker to Great Jones streets, 500 feet, at $600,....	300,000	
From 8th-street to 4th Avenue, 150 feet, at $600,	90,000	
From 17th-street to 23d-street, 1,200 feet, at $600,	720,000	
For Depot, near 42d-street,....................	261,000	
For 3 Stations,...............................	210,000	
		1,806,000
Contingencies, &c., &c., 15 per cent.,........................		1,318,085
Total from Broadway to 46th-street,......................		$10,105,318

SECOND SECTION—FROM 46TH-STREET TO HARLEM RIVER.

152,865 cubic yards of earth excavation, drainage, &c., &c., at $1 50 per cubic yard,.............	$229,297	
176,020 cubic yards rock excavation, at $4,......	712,080	
124,000 " " " " in Tunnel, at $6,......................................	744,000	
8,250 running feet of brick viaduct, ...	1,072,500	
		$2,757,877
55,850 cubic yards of brick masonry in Tunnel, at $16,.................................	$893,600	
59,000 cubic yards of rubble masonry, at $10,....	590,000	
44,250 " " concrete, at $8,...........	354,000	
		1,837,600
Carried forward, ...		$4,595,477

Brought forward,		$4,595,477
Changing water pipes and sewers,		100,000
7 Passenger Stations,	$350,000	
5 Ventilating Stations and Engines,	280,000	
Telegraph and Gas Fixtures,	30,000	
Land for Stations,	140,000	
		800,000
8 miles of Single Track and Ballast,		319,640
14 Engines, at $16,000,	$224,000	
100 Cars, at $5,000,	500,000	
		724,000
Contingencies, &c., &c., 15 per cent.,		980,866
Total from 46th-street to Harlem River,		$7,519,983

RECAPITULATION.

First Section,	$10,105,318
Second Section,	7,519,983
Total from Broadway to Harlem River,	$17,625,301

In suggesting the probable revenue of your road, we are without positive data for such a road as you propose to build and furnish, but we have data which will give a degree of confidence to such an estimate.

The passenger traffic in New-York has increased from the few millions (probably two or three) formerly carried by the public coaches, to the number of 90,000,000 carried last year, within the city, by the omnibuses, rail-road cars and steamers plying between Harlem and South-street; of the crowds who seek passage in the horse cars, barely two-thirds get seats in the morning and evening cars.

This increase is vastly beyond the proportional increase of the people or of the trade of the city, within the time of the increase of this traffic, and seems only to be limited by the facilities for transit.

By referring to Appendix "C.," it will be seen that the estimated gross revenue of the Railway to Forty-sixth-street is $4,319,400 per annum; the cost of operating the road is estimated at $1,916,000 per annum. There would then be a net income of 23 783-1000 per cent. on the estimated cost of that portion of the road, which, we take it for granted, will be first put in operation. The fast growth of the city, we think, warrants the belief that in a very few years the extension of the road to Harlem River would be a remunerative investment. We, therefore, report the opinion expressed at the commencement, "that the work in question will pay."

Respectfully submitted.

W. W. Evans,
E. S. Chesbrough,
George S. Greene.

New-York, *Oct.* 19, 1869.

Appendix A.

HOT WATER ENGINES.

Tyndall says that heat is force. It is force that we require. If heat is the same thing, then we require heat which we can convert into force at will. Now, it is not convenient to carry a Heat-Factory with us on the Railway and make the heat as it is required. The next step is to create the heat in a stationary factory and store it, ready to be drawn off and used. Can this be done? I think it can. I find it admitted that more units of heat can be stored in a given weight of water than in any other substance. Physicists have determined how many units of heat or work there are in a pound of water for each degree of increased temperature. With these elements it was very easy to determine how many cubic feet of water, heated to a temperature of 470°, (equal to 500 pounds per square inch,) would take a train of ten sixty seat cars up a gradient of 100 feet per mile (1 in 53) at a speed of 20 miles per hour, for a distance of one mile; also, what water, heated in the same way, would take the same train on a level one mile. I find that 63 c. ft. will take the first, and 10½ c. ft. will take the second. If these calculations are correct, it will be an easy matter to construct an engine that will carry a train with 600 passengers from City Hall to Harlem with steam flashed from one charge of hot water.

I have received from others similar calculations, with about the same results; if there are difficulties connected with this system, they are mechanical and not physical. By the use of hot water—or rather the steam flashed as required from hot water—the tunnel will be free from smoke and cinder, which we all know detract so much from the pleasure of traveling by rail; it will also be free from the poisonous effects of carbonic acid gas, which is generated in great quantities wherever heat is generated; the vapor of water which will be thrown from the cylinders of the locomotives can be carried off by ventilators provided for the purpose. It might be claimed by some, that the use of water at the high temperature I propose, would be dangerous. I would say, in answer, that it is as easy and as certain for an accomplished engineer to construct a boiler to hold steam at a pressure of 1,000 pounds to the square inch, as it is to construct one to hold steam at 50 pounds; that there is a larger per centage of explosions of boilers using steam below 50 pounds, than there is of boilers working over 100 pounds. I would give as a reason for this, that there is more care and skill devoted to the latter than the former, in the making, and in the handling; also, that they are generally attached to more costly engines. I have seen an engine run in the City of London, with a pressure of 1,500 pounds per square inch. The boilers had been tested to 2,000 pounds per square inch, and had an ultimate strength of 20,000 pounds per square inch. Jacob Perkins always used steam at 600 pounds per square inch, in his steam gun, and never had a failure; his son, Angier Perkins, supplied the steam-heating apparatus for the British Museum, the Euston Square Railway Station, the houses of the Duke of Wellington, and many other well known buildings in London, and never met with an accident that I ever heard of. He showed me that he was running this steam-heating apparatus in his works, regularly at a pressure of 2,000 pounds per square inch. At the works of Mr. Perkins are made the Portable Cooking Ovens now in general use in the British Army. These ovens are constructed of gas pipes, welded up at both ends, and containing water; there is no escape for steam at any pressure, and there is no fear of explosions, for there is strength to resist any pressure that can be attained, when used as they are, with 18 inches (out of 11 or 12 feet) in the fire. I have seen these pipes made, and the water run into the red-hot iron when the second end was closed.

Hearing that an experiment had been made in Philadelphia with a hot water engine, I went there, and after some difficulty I discovered that this engine was built by Messrs. Grice & Long, builders of small engines for street railways and mines. They gave me the particulars of their engine, and told me that the experiment was not fully and fairly tested, as they had not a competent boiler to heat the water and charge the reservoir of the engine. They intended getting a uniform temperature of about 344° F. to the water. This corresponds with 125 pounds pressure. They could not get a uniform temperature to the water above 320° F. This corresponds with a pressure of 90 pounds. With this they run the engine backwards and forwards in their yard (on a track roughly constructed for the purpose) at a speed of six miles an hour for 45 minutes, and made 125 stops. Now, if this data is correct, it goes far to prove what I have written in reference to the power that can be stored up in water and held subject to command. The matter is worthy of great consideration, and a series of well conducted trials, commencing with a first class ordinary locomotive, prepared for the purpose, and supplied with hot water from the boilers of two other locomotives. If these results are satisfactory, the experiments might be carried to the point proposed by an apparatus constructed expressly for the purpose.

ESTIMATE OF THE EFFICIENCY OF THE WATER ENGINES.

The expansion of water into steam consumes a large proportion of the heat in it, but as this is the case with any boiler, there is no especial loss on this account. A much more serious objection is the loss in expansion from a pressure of 500 pounds per square inch to about 150, where the temperature is low enough for use in an ordinary cylinder. There is a loss in heating water above a pressure at which it is to be used.

Calling the original temperature T and the temperature at which the steam is used $T,$ and the latent heat at the lower temperature l, and the proportion of the water vaporized at the lower temperature x, we get $T = T, (1 - x) + (l + T.)\, x \therefore x = \frac{T - T,}{l.}$ From Rankine we get $l = 1114^{\circ} - O.\ 7\ T,$ approximately. In the following table it is assumed that the pressure in the boiler is 500 pounds, and that the steam from it is throttled down to the lower pressures shown in the first column:

Pressure in pounds above the atmosphere.		Temperature. Fah't.	Latent Heat.	Proportion vaporized.	Specific Volume.	Ft. lbs. Power at full stroke.	Ft. lbs. Power cut of at ⅓.
Sq. Inch.	Sq. Foot.					Pr. Cub.Ft	HotWat'r.
500	72,000	470°	795°	....	56	....	....
400	57,600	448°	802°	.027	71	111,419	220,838
300	43,200	421°	819°	.060	92	238,464	476,928
200	28,800	388°	842°	.097	132	368,755	737,510
150	21,600	366°	858°	.121	169	441,698	883,398
125	18,000	353°	867°	.135	197	478,710	957,420
100	14,400	338°	878°	.150	237	511,920	1,023,840
75	10,800	320°	888°	.169	298	543,909	1,087,818
50	7,200	298°	905°	.190	405	554,040	1,108,080
25	3,600	267°	927°	.219	640	504,576	1,009,152

From the foregoing table it will be seen that if the steam is to be all taken at one pressure, the maximum effect will be at a pressure of between 50 and 75 pounds per square inch; but as the steam is to be expanded three times, it will be best to assume a pressure of 100 lbs. per square inch.

The most effective way would be to use the steam at a very high pressure and great expansion at first, using two cylinders if necessary, and, as the pressure diminished, increasing the amount of admission, but it would not be advisable to calculate on this for a locomotive engine.

WORK IN ONE CUBIC FOOT OF HOT WATER AT 470°

	Foot-Pounds.
Steam taken 100 lbs.	
Cut off at ⅛,..	1,023,840
Deduct for Clearance, 10 per cent, " " Radiation, 5 " " " " Extra Steam Space, 10 per cent.	255,960
Work per C. Ft. Hot Water in Boiler in Ft. Pounds,............	767,880

ESTIMATE OF AMOUNT OF HOT WATER, SIZE OF BOILERS, ETC., NEEDED TO HAUL TRAINS.

The passenger trains on the Underground Railway will weigh about as follows:

	Pounds.
10 sixty-seat Passenger Cars, each 30,000 lbs.,.................	300,000
1 Engine,..	65,000
Weight of Train in pounds,.........................	365,000

RESISTANCE TO TRAIN ON A LEVEL AT 20 MILES AN HOUR.

Resistance due to rolling friction, 182½ tons, @ 6 lbs.............	1,095
" of air, 100 Sqr. Ft., @ 3 lbs.,.........................	300
Friction of Engine, 10 per cent. of Traction,......................	140
Tractive force required on a level in pounds,...............	1,535

CUBIC FEET OF HOT WATER REQUIRED PER MILE ON A LEVEL.

$$\frac{1,535 \text{x} 5,280}{767,880} \text{ .... } 10½ \text{ cubic feet.}$$

RESISTANCE TO TRAIN ON AN INCLINE OF 100 FEET PER MILE, OR 1 IN 52.8, AT 20 MILES PER HOUR.

Resistance due to Rolling friction, as before,......................	1,095
" " " Air,..	300
" " " Gravity, $\frac{365,000}{5,280}$	6,913
" " " Friction of Engine, 10 per cent.,................	831
Traction force required on an incline of 1 in 52.8,...........	9,139

CUBIC FEET OF HOT WATER REQUIRED PER MILE ON THIS INCLINE.

$$\frac{9{,}139\text{x}5{,}280}{767{,}880} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\; 63 \text{ cubic feet.}$$

STOPPAGES AT STATIONS.

It is proposed to put short steep inclines of 1 in 52.8, with a descent of about 10 feet each way from stations. If the station tracks are level for 500 feet, the centre of gravity of trains will have to be moved 250 feet before reaching the incline. The full power of the engine should be used on this; and as it is assumed sufficient to start the train on an incline of 1 in 52.8, this will be equivalent in power to lifting the train bodily 5 feet. The steep incline will add the additional velocity required, which will be expended in ascending the next incline. The engine will therefore have only to expend 5'x365,000=1,825,000 foot-pounds power at each stopping place, in addition to the power required to move train 20 miles an hour steadily.

ESTIMATE OF WEIGHT OF ENGINE REQUIRED TO HAUL TRAIN ENTIRE LENGTH OF LINE.

City Hall to Harlem, say..............................	41,000 feet
Resistance due to distance, 41,000 x 1,535,...............	62,935,000
" " Sum of ascents, 365,000 x 68,.............	24,820,000
" " 11 stopping places, 365,000 x 11 x 5,........	20,075,000
Foot pounds of work to do,..........................	107,830,000

BOILER SPACE REQUIRED.

$$\frac{107{,}830{,}000}{767{,}880} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\; 140 \text{ cubic feet.}$$

If the hot water is carried in tubes 12 internal diameter, ⅜ inch thick, they will weigh 50 pounds per lineal foot, and 178 lineal feet will be required.

Assuming, that to cover contingencies, 200 lineal feet of tubes are used, the weight of engine will be about as follows:

	Pounds.
200 feet Tubes, @ 50 lbs.,	10,000
150 c. ft. of Hot Water, at (470°=55 lbs.,)	8,250
Ends, Connections, &c., for Tubes, &c.,	3,000
Water for Condensing 500 gallons,	5,000
Frame, Engines, Wheels, Axles, Machinery, &c.,	38,750
Total weight of Engine,	65,000

The foregoing shows the practicability of using engines run by one charge of hot water from City Hall to Harlem.

Should this estimate of water required be 50 per cent. too small, it can be remedied by adding not over 12 tons of water and reservoir pipes to the engine, and still leave it in weight some tons less than the engines used on the Metropolitan Railway of London. But I would here state again my conviction, that this Railway, using the ordinary engine, manufacturing its power as it runs, can be worked in a continuous tunnel, and the tunnel efficiently ventilated, at less expense than it can be worked by the hot water engines.

The advantages of the Hot Water System would be freedom to the passengers from smoke, cinder and carbonic acid gas, also a less expensive ventilating apparatus. Its disadvantages would consist in its being a new system, with all its detail remaining to be worked out and perfected. If the road is built for the ordinary engines, the Hot Water System can be adopted at any time when it can be declared perfected.

The figures I have presented show such favorable results, that I deem the system worthy of a series of carefully conducted experiments.

Appendix B.

UTILIZING GRAVITY AT STATIONS.

You will see by the section or profile of the route, that I have placed the stations about half a mile apart, and undulated the gradients so that each station is placed on a summit. In operating a railway of the kind proposed, it is important to lose as little time at the stations as possible, in either stopping or starting; it is important to keep up a rapid speed to a point as near the station as possible, and in starting to get the train under full speed in as small a space of time as possible. In London the trains are run at full speed to a point within a short distance of the station, when the brakes are whistled down, and down they all go, by the prompt use of well-trained, brawny arms scotching many of the wheels, and at night creating a most magnificent display of fireworks as each wheel planes off a part of their 84 pounds steel rail. (I send you a section of this rail showing the planing that was done in three years.) The train is started and got under full speed in a remarkably short space of time and distance, but this is done entirely by the possession of a large surplus of engine power; now this system of stopping and starting involves, in the first place, the entire loss of the "*vis viva*" existing in the train, the sum of its weight and speed; it is annihilated by the brakes, and lost forever, thrown away as if it did not cost any thing to create it. In addition to this loss, there is from this excessive use of the brakes another serious loss from the rapid destruction of the rails, and cars and engines, the engines being often reversed, and the steam used to assist in destroying what it had created; the system also involves the use of very heavy engines, weighing, I am told, 55 tons.

To provide, in a simple manner, against the entire loss of the "*vis viva*" or momentum of the train in stopping at stations, and to insure that the stopping and starting is done in the most efficacious and expeditious manner, I would propose to bring the great power of gravity to assist, both in stopping and starting; in view of this, I have placed every station on a summit especially provided for it. By this system what is apparently lost in stopping, is again recovered in starting; this could easily be arranged, so that, at a fixed speed, the brakes would hardly be required.

Appendix C.

Estimate of Passenger Traffic which the Underground Railway will probably command.

	Going up.	Com'g down.
5 to 6 o'clock, A. M.,	1,000	2,000
6 “ 7 “ “	1,000	4,000
7 “ 8 “ “	2,000	10,000
8 “ 9 “ “	3,000	11,000
9 “ 10 “ “	5,000	11,000
10 “ 11 “ “	6,000	10,000
11 “ 12 “ M.,	7,000	9,000
12 “ 1 “ P. M.,	7,000	7,000
1 “ 2 “ “	8,000	8,000
2 “ 3 “ “	8,000	8,000
3 “ 4 “ “	10,000	7,000
4 “ 5 “ “	11,000	6,000
5 “ 6 “ “	11,000	5,000
6 “ 7 “ “	10,000	4,000
7 “ 8 “ “	9,000	4,000
8 “ 9 “ “	7,000	3,000
9 “ 10 “ “	6,000	3,000
10 “ 11 “ “	2,000	2,000
11 “ 12 “ M.,	1,000	1,000
	115,000	115,000

Total for one day,......... 230,000
“ 313 week days,.. 71,990,000

71,990,000 per annum, at 6 cents,.... $4,319,400

The above does not include the extra fare that might be charged for carrying first class passengers, or for carrying "goods," express parcels, or the mails, or rents of property belonging to the Company and not used for railway purposes, or for Sunday traffic, or Feast day crowds. Assuming that there will be 300 trains a day in each direction, that each train is made up of 10 carriages, and the distance run five miles, there will be for 313 days, a car mileage of 9,390,000
And a train mileage of...................... 939,000

ESTIMATE OF OPERATING EXPENSES.

Maintenance of way, 12 miles, at $2,000,	$24,000
Cost of rails, supposing rails to last six years,	51,000
Repairs of buildings, say	20,000
Taxes (State) on real estate,	25,000
" (National) on earnings and dividends,	216,000
25 Ticket Agents, at $2,000,	50,000
24 Telegraph operators, at $1,500,	36,000
70 Station guards, at $1,000,	70,000
Repairing of engines and cars, supplies, wages, train hands, &c., at $1 per train, mile run,	939,000
Deterioration of cars and engines, supposing them to cost $1,500,000, and worthless after 12 years' service,	125,000
Ventilation of tunnel, by 10 engines,	50,000
Gas in tunnel and cars, offices, &c.,	110,000
Salaries and office expenses,	50,000
Miscellaneous and contingencies,	150,000
Total expenses,	$1,916,000
Gross revenue, as above,	4,319,400
Net revenue,	$2,403,400

Or nearly 22 per cent. per annum on an expenditure of eleven millions of dollars, ($11,000,000.)

We may have over-estimated the passenger traffic, but considering that the street railways are carrying 233,000 passengers a day; that they run but little faster than a man can walk; that passenger traffic always increases with increased facilities; that the population and wealth of the city is increasing with a rapidity almost unexampled in the history of any city; that additional fares above six cents can and will be collected from first class passengers from Sunday traffic, from extra travel on celebration and feast days, from rents and from goods' traffic. it is but reasonable to suppose that the above estimate will be met and exceeded, on the three and a half (3½) miles estimated for, as soon as the road is opened, and that a handsome addition may be expected as soon as the Cross-Town Street Railways are built, as they will be, in the upper part of the city to bring traffic to your Railway.